

**OXFORD CAMBRIDGE AND RSA EXAMINATIONS**

**Advanced GCE**

**CHEMISTRY**

Chains, Rings and Spectroscopy

Thursday

**23 JUNE 2005**

Afternoon

1 hour 30 minutes

**2814**

Candidates answer on the question paper.

Additional materials:

*Data Sheet for Chemistry*

Scientific calculator

Candidate Name

Centre Number

Candidate  
Number

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**TIME** 1 hour 30 minutes

**INSTRUCTIONS TO CANDIDATES**

- Write your name in the space above.
- Write your Centre number and Candidate number in the boxes above.
- Answer **all** the questions.
- Write your answers in the spaces provided on the question paper.
- Read each question carefully and make sure you know what you have to do before starting your answer.

**INFORMATION FOR CANDIDATES**

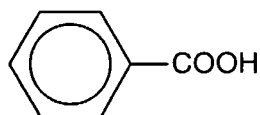
- The number of marks is given in brackets [ ] at the end of each question or part question.
- You will be awarded marks for the quality of written communication where this is indicated in the question.
- You may use a scientific calculator.
- You may use the *Data Sheet for Chemistry*.
- You are advised to show all the steps in any calculations.

FOR EXAMINER'S USE		
Qu.	Max.	Mark
1	10	
2	15	
3	13	
4	15	
5	20	
6	17	
TOTAL	90	

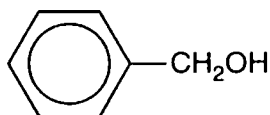
**This question paper consists of 16 printed pages.**

Answer all the questions.

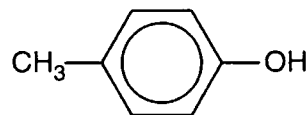
- 1 A student decided to investigate the reactivity of the  $\text{-OH}$  group in the three organic compounds shown below.



benzoic acid

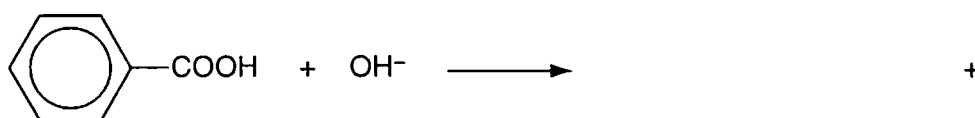


phenylmethanol



4-methylphenol

- (a) Benzoic acid reacts with aqueous sodium hydroxide.



- (i) Complete the equation above. [2]
- (ii) State which, if any, of the other two compounds above would react with aqueous sodium hydroxide. Explain your answer.

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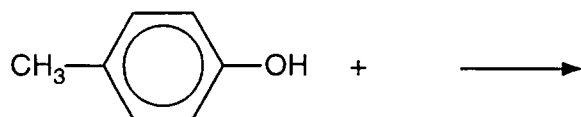
.....

.....[2]

- (b) All three compounds react with sodium metal, giving off a gas.

- (i) Identify the gas given off in this reaction.
- .....[1]

- (ii) Complete and balance the equation for the reaction of 4-methylphenol with sodium.



[2]

(c) Benzoic acid and phenylmethanol will react with each other in the presence of a suitable catalyst.

(i) State a suitable catalyst for this reaction.

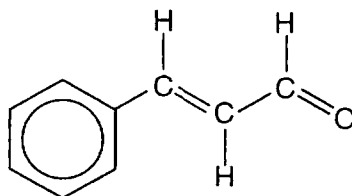
.....[1]

(ii) Draw the displayed formula of the organic product.

[2]

[Total: 10]

- 2 Cinnamaldehyde is the compound that gives cinnamon its distinctive flavour.



cinnamaldehyde

- (a) Draw the skeletal formula of cinnamaldehyde.

[1]

- (b) Cinnamaldehyde shows *cis-trans* isomerism.

- (i) Explain how *cis-trans* isomerism arises in cinnamaldehyde.

.....  
 .....  
 .....  
 .....[2]

- (ii) State and explain whether cinnamaldehyde is a *cis* or a *trans* isomer.

.....  
 .....[1]

- (iii) Draw a skeletal or displayed formula to show the structure of the other *cis-trans* isomer of cinnamaldehyde.

[1]

- (c) Cinnamaldehyde can be reduced using sodium borohydride, NaBH<sub>4</sub>.

- (i) State which functional group reacts with the sodium borohydride.

.....[1]

- (ii) Complete and balance the equation for this reaction.



[1]

Tollens' reagent can be used to identify the aldehyde group in cinnamaldehyde.

- Describe how you would make Tollens' reagent and carry out this test in the laboratory.
- Explain what happens to both the Tollens' reagent and the cinnamaldehyde in this reaction. Identify the organic product.

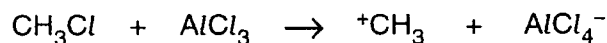
[7]

[Total: 15]

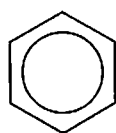
- 3 Benzene reacts with  $\text{CH}_3\text{Cl}$  to form methylbenzene  $\text{C}_6\text{H}_5\text{CH}_3$ . This is an electrophilic substitution reaction.

A possible mechanism for this reaction is shown below.

**Step 1:** the electrophile  $^+\text{CH}_3$  is formed from  $\text{CH}_3\text{Cl}$  and the catalyst,  $\text{AlCl}_3$



**Steps 2 and 3:** substitution of  $^+\text{CH}_3$  into the benzene ring



step 2  
→

step 3  
→

intermediate

products

**Step 4:** the catalyst,  $\text{AlCl}_3$ , is regenerated

- (a) (i) Complete **steps 2 and 3** of the mechanism above. Show the relevant curly arrows and the charges on any ions. [4]

- (ii) State why  $^+\text{CH}_3$  is described as an electrophile in this mechanism.

.....  
.....[1]

- (iii) Suggest an equation to show how the catalyst,  $\text{AlCl}_3$ , is regenerated in **step 4**.

[1]

- (b) Write an overall equation for this reaction.

[2]

(c) This substitution reaction occurs much more readily with phenol than with benzene.

- (i) State and explain why electrophilic substitution reactions occur much more readily with phenol than with benzene.

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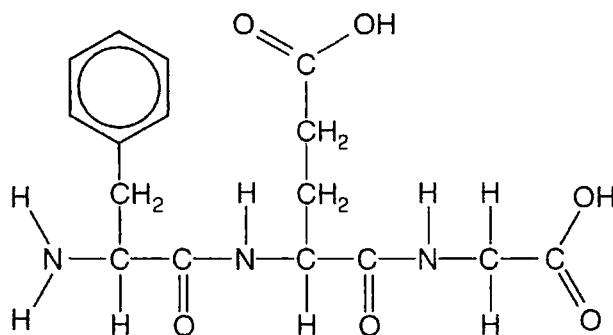
.....[4]

- (ii) Suggest a structure for the most likely organic product formed in the substitution reaction of phenol with **excess**  $\text{CH}_3\text{Cl}$ .

[1]

[Total: 13]

- 4 Compound **A** is currently being tested as a possible anti-allergic drug.



compound **A**

- (a) Compound **A** can be hydrolysed to form three organic products.

- (i) Name a suitable reagent and conditions for the hydrolysis of compound **A**.

.....  
 .....[2]

- (ii) The three organic products all belong to the same class of compound. State the general name for this class of organic compound.

.....[1]

- (iii) Draw the structure of **one** of the organic products from the hydrolysis of **A** using the reagent you have given in (a)(i) above.

[2]

- (iv) Explain what is meant by the term *hydrolysis*. Use this reaction to illustrate your answer.

.....  
 .....  
 .....[2]



(b) Compound **A** can exist as a number of stereoisomers, but only one of them is pharmacologically active as the anti-allergic drug.

(i) Explain what causes stereoisomerism in compounds such as **A**.

.....

.....

.....

.....

.....

.....

.....[3]

(ii) Explain why there are **four** different stereoisomers of compound **A**.

.....

.....

.....[2]

(iii) Suggest how a drug company could synthesise compound **A** so that the drug contains only the pharmacologically active stereoisomer.

.....

.....[1]

(iv) Sometimes it is difficult to manufacture a drug containing only the one pharmacologically active stereoisomer.

Describe **two** possible disadvantages of producing a drug containing a mixture of several stereoisomers.

.....

.....

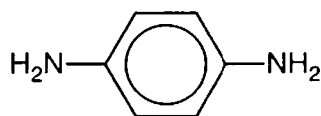
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.....[2]

[Total: 15]

- 5 1,4-Diaminobenzene is used in the manufacture of a variety of materials including dyes and polymers.

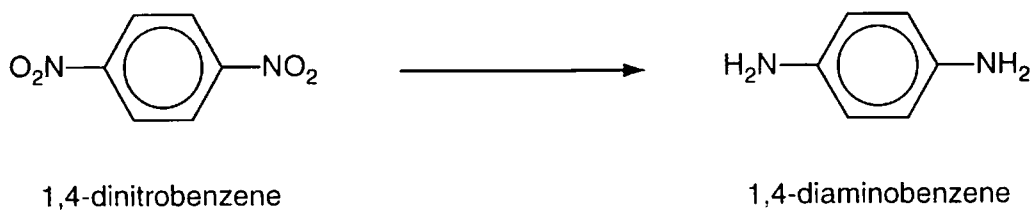


**1,4-diaminobenzene**

- (a) Explain what is meant by the term *1,4-diamino* in the name of this compound.

.....  
 .....  
 .....[2]

- (b) 1,4-diaminobenzene can be manufactured from 1,4-dinitrobenzene.



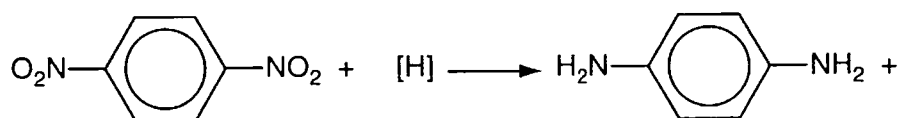
- (i) What type of reaction is this?

.....[1]

- (ii) State reagents and conditions that could be used to carry out this reaction.

.....  
 .....[2]

- (iii) Complete and balance the equation below for this reaction.



[2]

- (c) 1,4-Diaminobenzene is used to make permanent black dye for hair.

1,4-Diaminobenzene can irritate the skin because it is basic. Therefore, it is sometimes neutralised with **excess** hydrochloric acid to give the salt.

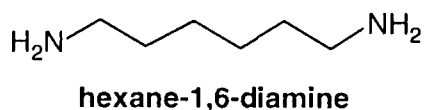
- (i) Explain how the amino groups in a primary amine such as 1,4-diaminobenzene allow the molecule to act as a base.

.....  
.....  
.....[2]

- (ii) Draw the structure of the salt formed in this reaction.

[2]

- (iii) State whether you would expect hexane-1,6-diamine to be a stronger or weaker base than 1,4-diaminobenzene. Explain your reasoning.



.....  
.....  
.....  
.....  
.....[3]

(d) Kevlar is a very tough polymer made from 1,4-diaminobenzene and benzene-1,4-dicarboxylic acid.

(i) State a use for Kevlar.

.....[1]

(ii) Describe the polymerisation reaction that forms Kevlar. Include in your answer:

- an explanation of the type of polymerisation involved
- an equation for the reaction
- a repeat unit to show the structure of Kevlar.

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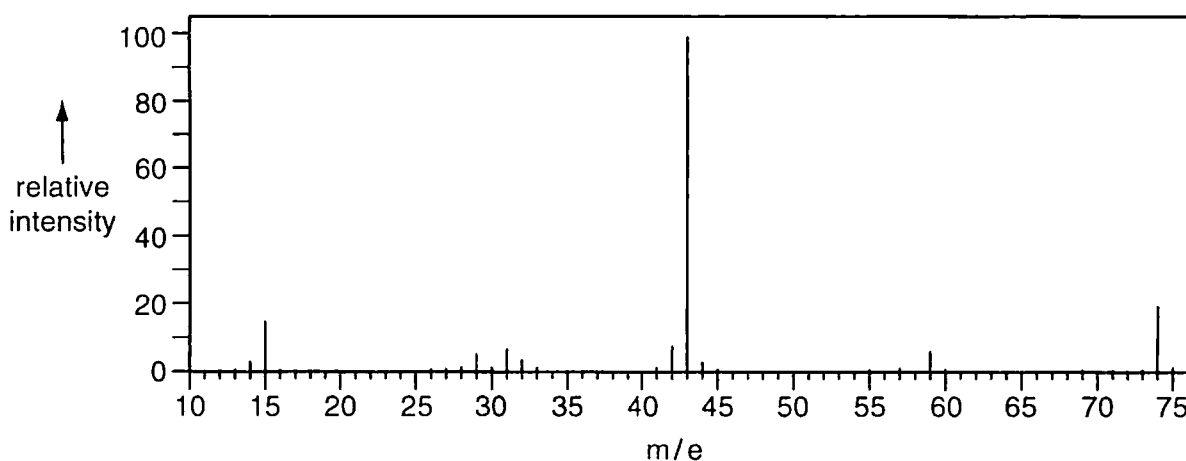
.....[5]

[Total: 20]

6 An unknown organic compound **X** was analysed as follows.

(a) Elemental analysis showed that compound **X** had an empirical formula of  $\text{C}_3\text{H}_6\text{O}_2$ .

The mass spectrum of **X** is shown below.



Show how the molecular formula of compound **X** can be deduced from the information above. Explain your reasoning. Circle the peak you have used on the spectrum.

.....  
 .....  
 .....  
 .....  
 .....[3]

(b) (i) Compound **X** did **not** give a precipitate with 2,4-dinitrophenylhydrazine.

State what this tells you about compound **X**.

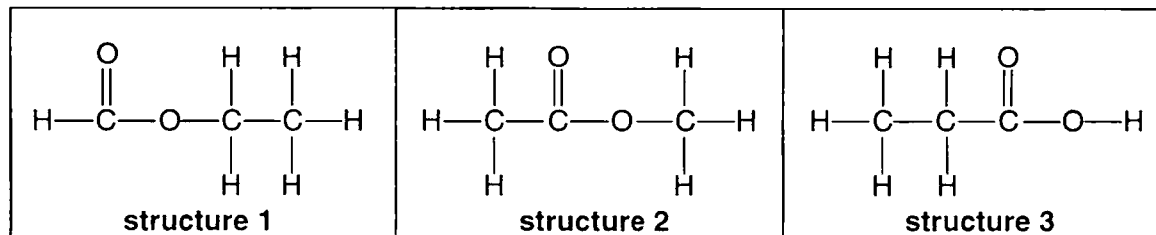
.....  
 .....[1]

(ii) Compound **X** did **not** decolourise bromine water.

State what this tells you about compound **X**.

.....  
 .....[1]

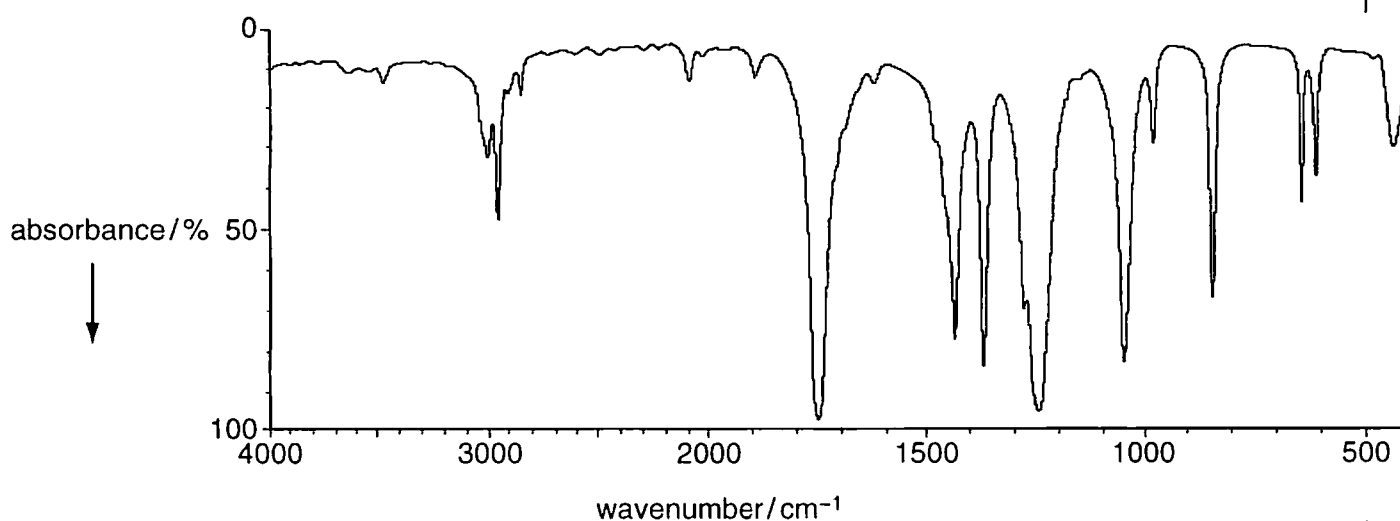
(c) Three structures for compound **X** were suggested.



State the name of: **structure 1** .....

**structure 3** .....[2]

(d) The infra-red spectrum of compound **X** is shown below.



For **each** of the three **structures 1** to **3**, state whether this spectrum supports its identity as compound **X** or not. Explain your reasoning by commenting on the presence or absence of the relevant peaks.

.....

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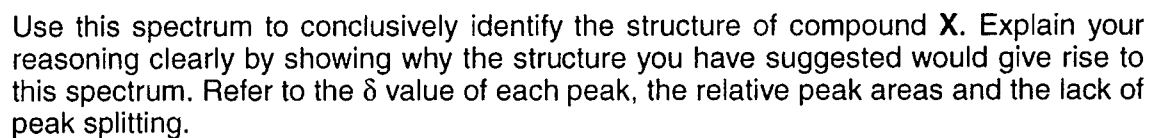
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.....

.....[4]

- The n.m.r. spectrum of compound **X** is shown below.



--

.....[5]

[Total: 17]

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*Copyright Acknowledgements:*

- Q.6(a) mass spectrum <http://www.aist.go.jp/RIODB/SDBS> (4/6/03) © SPECTRAL DATA BASE SERVICE (SDBS).  
(d) infra-red spectrum from <http://www.aist.go.jp/RIODB/SDBS> (4/6/03) © SPECTRAL DATA BASE SERVICE (SDBS).  
(e) mass spectrum from <http://www.aist.go.jp/RIODB/SDBS> (4/6/03) © SPECTRAL DATA BASE SERVICE (SDBS).

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